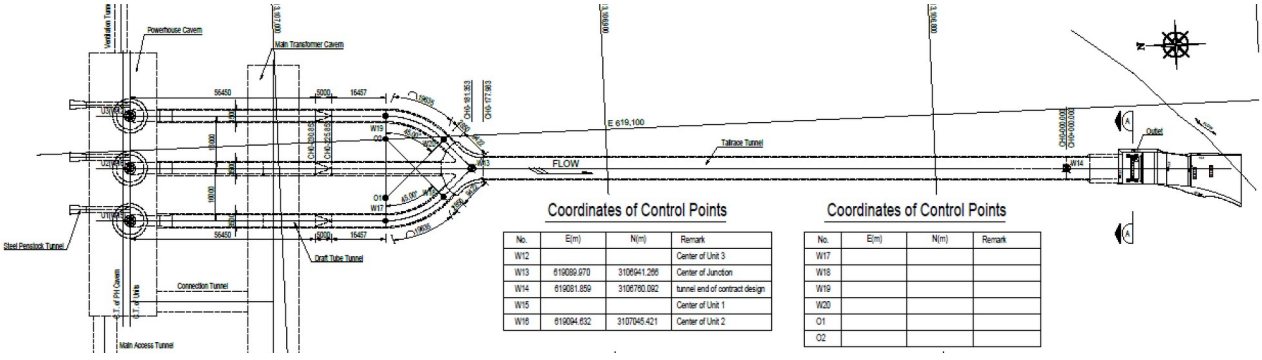
Tasks for CFD (Computational Fluid Dynamics) analysis for Tailrace tunnel of Upper Trishuli-1 HEP

1. Background

Upper Truishuli-1 HEP is a long diversion high head hydropower project, the headrace and power generation system is located on the right bank with the total installed capacity of 216MW, it mainly consists of a power intake, 3-bay desander basin, 10km long headrace tunnel, a headrace surge tank, a pressure shaft, 3 penstocks with 2 Y-bifurcations, an underground powerhouse housing 3 Francis type turbine-generator units with the single unit capacity of 72MW, 3 draft tube tunnels 3 tailrace surge shafts, a trifurcation tunnel and 1 tailrace tunnel. Layout of the tailrace system of UT-1 is as shown in Figures 1.1~1.2.



No.	E(m)	N(m)	Remark
W12			Center of Unit 3
W13	619089.970	3106941.266	Center of Junction
W14	619081.859	3106760.092	tunnel end of contract design
W15			Center of Unit 1
W16	619094.632	3107045.421	Center of Unit 2

No.	E(m)	N(m)	Remark
W17			
W18			
W19			
W20			
O1			
O2			

Figure 1-1 Tailrace system layout plan

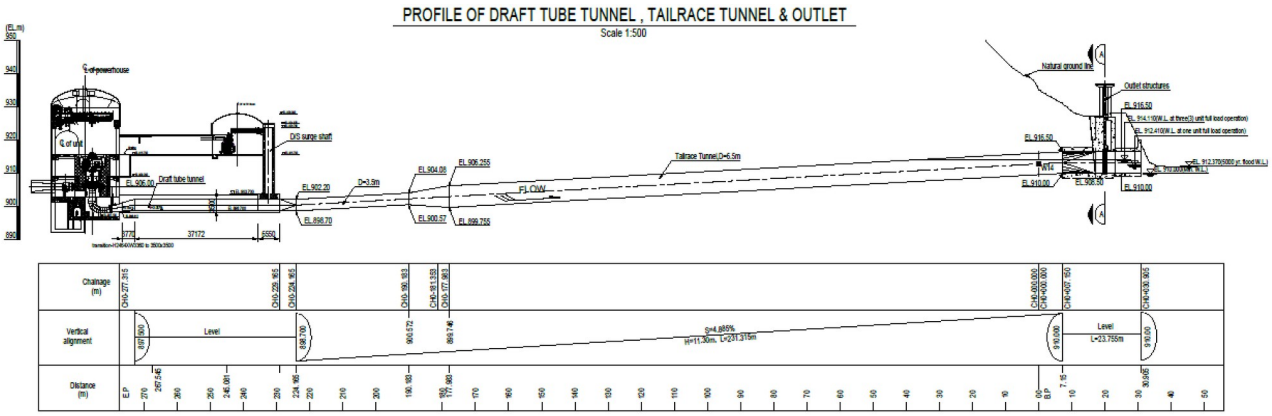


Figure 1-2 Tailrace system elevation view

In order to avoid potential ingress of silt into the tailrace tunnel during flood season, the outlet of the tailrace tunnel was arranged highly above the flood level of the river.

Transient analysis of the headrace and power generation system shows that the pressure line is only slightly over the tailrace tunnel crown in case of load variation, e.g. load rejection or load acceptance.

In the review report drafted by LTA (Lender's Technical Advisor) as well as a meeting held at site on May 3rd~4th, CFD analysis was requested to be done to confirm the behavior of the water profile over the full length of the tunnel since the LTA has concerns about transient conditions inside the tunnel on the liner.

2. Basic Data

2.1 Discharges and water levels

No.s of unit	Discharge (m^3/s)	Tailrace outlet water level (m)
1	25.33	912.41
2	50.67	913.38
3	76	914.11

2.2 Parameters of the unit

Turbines: Vertical Francis turbines

Runner diameter: D2 1.580 m

Rated speed: N 428.57 rpm

Runner Centerline: CL 906.0 masl

Max. static head: Hstmax 349.0 m (1255-906)

Turbine max. power: Pmax 74.5MW

Moment of Inertia: WR^2 187.5 tm^2

2.3 Opening and closing law of MIV(Main inlet valve)

The opening and the closing are done linear.

Linear, opening time from 0 to 100% Tg = 150 [s]

Linear, closing time from 100 to 0% Tf = 150 [s]

2.4 Distributor

The guide vanes are connected to two servomotors via a regulating ring. The modeled kinematic considers the relation between servomotor stroke and guide vane opening.

Guide vane closing and opening times are selected such that critical parameters like speed rise and pressure rise remain within contractual guaranteed limits.

The closing laws are described in following Table 2.1 and shown in the Figure 2.1.

Table 2.1 Closing law of guide vane

	T_f (Time, Fast slope)	Th (Time, Slow slope)	Yh (Slope change)
	[s]	[s]	[%]
Quick shut down triggered by electrical reason (QSD-E)	8.0	12	35

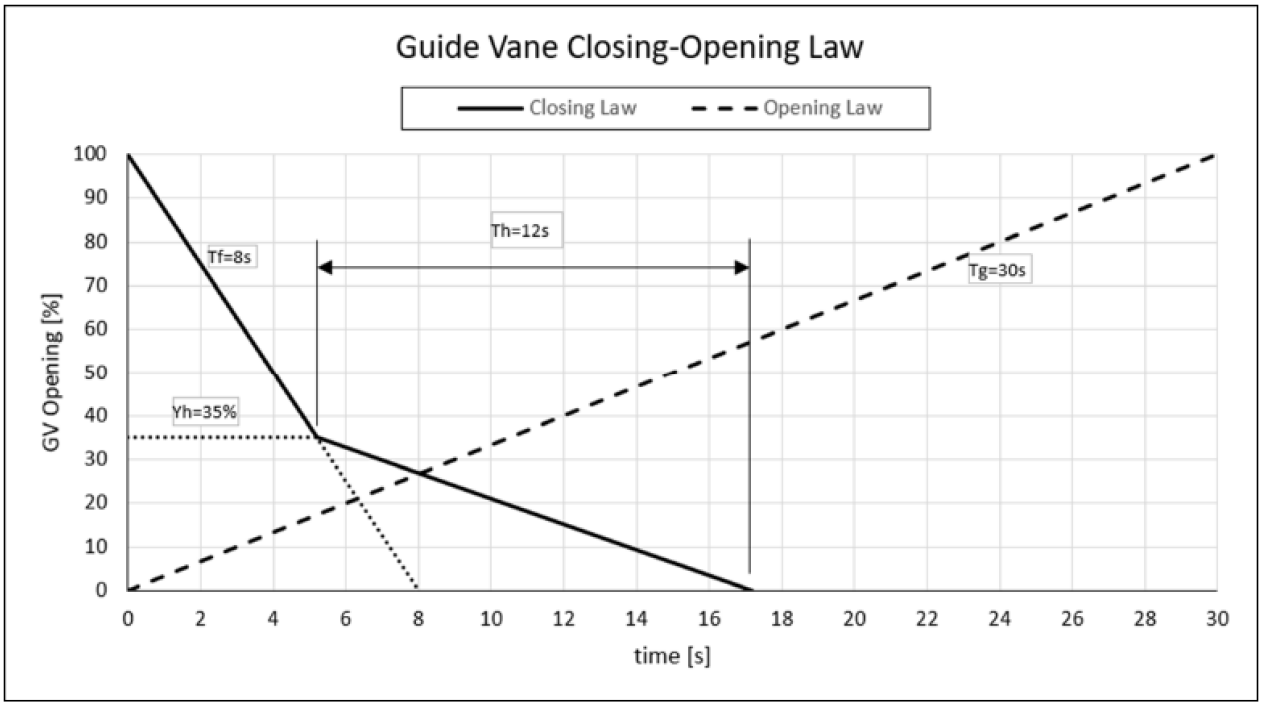


Figure 2.1 Guide vane closing-open law

1st Slope, Fast Closing (Tf): Guide vane will close in 8s.

2nd Slope, Slow Closing (Th): Guide vane will close in 12s.

Slope changes from 1st slope to 2nd slope (Yh): at 35% of Guide vane opening

The guide vane opening time (Tg) from 0 to 100% Load = 30s.

3. Major Tasks

(1) Carry out CFD analysis for steady flow with 1,2 and 3 units in full operation.

(2) Carry out CFD analysis for unsteady flow with load rejection of all 3 units in full operation (the most critical case for the tailrace tunnel water profile).

4. Requirements for achievements

4.1 Steady flow

(1) Water profile of 1 unit in full operation over the full length of the tunnel.

(2) Water profile of 2 of 3 units in full operation over the full length of the tunnel.

(3) Water profile of all 3 units in full operation over the full length of the tunnel.

4.2 Unsteady flow

(1) Variation process of the water profile over the full length of the tunnel with appropriate time interval, it needs to be noted that the total time duration should be no less than that of a complete water hammer.

(2) Variation process of the water level at surge shaft, beginning points and end point of the trifurcation, as well as the location 20m downstream of the trifurcation end point.